Original Article

Evaluation of Early Active Controlled Motion in Flexor Tendon Repair

Masoud Yavari; Ramin Farzam*
Panzdah Khordad Hospital
Shahid Beheshti University of Medical Science, Tehran, Iran

Azade Riyahi
Arak University of Medical Sciences, Arak, Iran

Objectives: The objective was to determine the results of early active controlled motion in the patients rehabilitated by our new protocol.

Methods: 91 fingers in 64 patients with flexor tendon repair in all zones were enrolled in a single group (quasi-experimental) clinical trial. 58 fingers in 43 patients were assessed at least three months postoperatively. Outcomes were defined using the 'White' criteria for thumbs and the 'Strickland' criteria for other fingers.

Results: The results for range of motion of fingers were Excellent in 70.7%, good in 13.8%, fair in 6.9% and poor in 8.6%. There were 3 (5.17%) postoperative tendon ruptures.

Discussion: Early active controlled motion with our rehabilitation protocol shows acceptable postoperative results.

This rehabilitation protocol is more effective if carried out from the 1st to 4th weeks after surgery, under the supervision of a surgeon or hand therapist. Then, from the 4th to 6th weeks, it should be performed at a hand therapy clinic and from the 6th to 12th weeks at home, supervised by a hand therapist.

Key words: flexor tendon, early active controlled motion, rehabilitation protocol

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Introduction

Flexor tendon tearing is a common injury which, if treated inappropriately, can result in a decrease in the range of motion and a loss of strength in the finger and hand. Different surgical and rehabilitation techniques have been invented for this problem. These methods have been improving since the 1970s, so it seems necessary to compile a surgical and rehabilitation protocol which is cheap and practical, especially in areas where occupational therapists and physiotherapists are not available. Postoperative rehabilitation protocols are divided into immobilization, early passive mobilization and early active controlled mobilization protocols. Selecting an appropriate protocol depends on patient conditions and surgical techniques (1).

Among these protocols, early active motion protocol is the newest and has had the best results (2,3).

Methods

The study protocol was approved by the Human Research committee of our institution. The study population was patients referred to the hand clinic or the emergency department of Panzdah Khordad Hospital between April and September 2014. The inclusion criteria were: aged 12 years or older, sharp injury of a flexor tendon in any zone of the hand, a duration of less than three weeks from injury till surgery, and a primary repair of the tendon, without any need for tendon transfer or tendon graft. Exclusion criteria were: age below 12 years, fracture in the same upper limb, extensor tendon injury in the same finger, bilateral digital artery injury, tendon avulsion and rupture requiring the tendon tenodesis method of surgery. All the patients were operated on by a single surgeon. The central part of the FDP tendon (core suture) was repaired by a 4 strand cruciate with 4-0 nylon, while the periphery of the

* All correspondence to: Ramin Farzam, email: <raminfarzam2007@yahoo.com>

tendon (epitenon) was repaired by running suture with 5-0 or 6-0 nylon, depending on tendon size. The suture segment was one cm, and the repaired site was tensioned to two mm. In cases of tendon entrapment under the pulley, venting was performed, and at least one third of the A2 pulley was saved. In cases where the repair site was under the A4 pulley, and full circle peripheral repair was impossible, a half circle repair was performed. FDS tears were repaired by a figure of eight suture with nylon 6-0 at slips, if it were possible (like FDP in other areas). In cases where there was a risk of jeopardizing FDP repair, only one or no slip was repaired. After surgery, all fingers except the thumb were immobilized in a dorsal blocking splint. The wrist was positioned at 0-10 degrees of extension, MCP at 60 degrees of flexion and the IP at 0 degrees of flexion. In cases of flexor pollicis longus repair, the wrist was immobilized at 0-10 degrees extension, MCP at 40 degrees of flexion and the IP at 0-5 degrees of flexion. The splinting period was 4 weeks. In the first three days, edema control was performed by slinging and elevating the injured limb, during the day and night respectively. On the second day, passive flexion and active extension started, and at the fourth day, early active controlled motion was started according to the Van Strien method. In this method, the uninjured hand is placed vertically on the distal palmar crease of the injured hand, and the injured finger flexes gradually and weekly on the second finger and then extends. Flexion is increased by gliding the injured finger on the second & third finger, and then extended the following week. This method is repeated for four weeks, until the injured finger reaches the fifth finger. In FPL repairs, the uninjured hand was placed vertical to the plane of thumb motion during opposition to the fifth finger. After four weeks, the splint was removed and the rehabilitation protocol carried out at an occupational clinic according to table (1).

Table 1. Early active mobilization protocol

Rehabilitation at home	Rehabilitation at occupational therapy clinic	Time after surgery
1- Elevation immediately after surgery 2- Shoulder and elbow elevation exercises. 3- Passive flexion-active extension exercises. From second day postoperatively 4- Active flexion-Active extension exercises. From 4th day postoperatively according to Van Strien method		1ed to 4th week
1- Moving the band in a basin filled with warm water 2- In case of edema, moving the hand in warm water for 3 and cold water for 1 min alternately, at least 3 times, each one for 15 min . 3- IP exercises: straight , hook and full fist 4- IP exercises with bread or game paste. 5- Place and hold exercises 6- Use of cream or ointments such as Vaseline or olive oil 7- Rubbing the hand with soft brush and smooth to rough clothes. 8- Squeezing sponges in basin filled with water 9- Isolated joint motion 10- Circling, deep pressure massage on suture site 11- Wearing disposable gloves at nights 12- Retrograde massage from distal to proximal	1- Paraffin bath for 10 min wearing disposable glove thereafter 2- IR for 15 min 3- Vibrator – IR massager equipment 4- Tendon Gliding Exercise 5- Soft putty 6- Place and hold exercise 7- Frictional and anti scar massage 8- Desensitization in case of nerve injury 9- Active flexion exercises. 10- Isolated joint motion 11- Passive stretching of finger	5th week
1- Previous exercise 2- With firm paste and wax 3- Positioning 4- Anti-deformity splint	1- Previous exercises 2- Putty resistive 3- Positioning 4- Anti-deformity splint	6th week
1- Use of light resistive instruments such as jelly balls, foams, etc.	1- Simultaneous wrist and finger extension 2- Putty resistive 3- Low resistance digi flex 4- Low resistance power web	7th week
1- Gradually strengthening exercises with different instruments such as digi flex, elastic rings.	1- Resisted composite, hook and straight fist 2- Resisted isolated joint motion 3- Job simulation 4- Continuation of progressive resistive exercises.	8th to 12th week

Demographic data including age, sex, injured finger, zone of injury, time from injury to repair, and concomitant injury or disease, were recorded by the questionnaire. This was administered before surgery, while the range of motion and tendon rupture (during rehabilitation) was assessed after surgery. At the end of the 12th week, the range of motion of the fingers were assessed by the 'White' criteria for thumbs and the 'Strickland' criteria for fingers. These were assessed by questionnaire and were analyzed by SPSS version 21.

Results

64 patients (91 fingers) were treated, and 43 patients (58 fingers) were followed at least for three months. 51 (71%) cases were men, 13 (21%) female. Fifth finger and zone II injuries were the most common finger and zone injuries (33.4% and 68.8% respectively). Three tendons ruptured postoperatively at the 4th, 10th and 6th week after surgery. None of them were in the thumb, and all were treated as per our surgery and rehabilitation protocol. Of these, one had an excellent result, and the other two were lost in the follow-up stage.

In FPL repair cases, 5 (55.6%) were excellent, 2 (22.2%) fair and 2 (22%) were poor. In total, according to the 'Strickland' and 'White' criteria, 41 cases (70.7%) were excellent, 8 good (13.8%), 4 fair (6.9%), and 5 poor (8.6%). 21 cases (32.6%) carried out rehabilitation at the hand therapy clinic and at home, as shown in table (2).

Table 2. Patient compliance with rehabilitation protocol

Rehabilitation at OTC* and home	number	Percent
All the rehabilitation protocol at OTC and home continuously	1	1.5
All the rehabilitation protocol at OTC and home intermittently	10	15.6
Only 10 sessions of rehabilitation at OTC and complete at home	6	9.3
Only 1-3 sessions of rehabilitation at OTC and incompletely at home	21	32.6
Rehabilitation only during the first 4 weeks postoperatively	64	100

*OTC: occupational therapy clinic

Discussion

Early active controlled mobilization needs a strong tendon repair. Factors affecting the strength of a surgical repair are as follows: 1) the number of suture strands across the repair site-strength is roughly proportional to the number of core sutures (4); 2) the tension of repairs (5); 3) the core suture purchase) (6); 4) the types of tendon-suture junction-locking or grasping (7); 5) the diameter of suture locks in the tendons-a small diameter of locks diminishes anchor power (8) ; 6) the suture calibers (diameter) (9) ; 7) the material properties of the sutures (10); 8) the peripheral sutures (11); 9) the curvature of the tendon gliding paths-the repair strength decreases as tendon curvature increases (12); and 10) above all, the holding capacity of the tendon, affected by the degrees of trauma and post-traumatic softening, is vital to strength. According to Strickland's research, at least a 4-strand repair is necessary in early active controlled mobilization. In this study, 4-strand cruciate repair for the core suture and running repair for epitenon was performed, and 6- and 8-strand repairs were avoided because of their complexity (13). Although fiber wire thread produce stronger repairs (14), and round needles are less harmful to the threads used in repair (15), we used nylon thread, which is cheaper, and round or cut needles as available. Thus cost, availability and simplicity were important factors for the authors. In a meta-analysis, the rate of tendon rapture after surgery was 3.6 to 10% from 1979 to 1998, and the range of motion results were good and excellent in 15.5% to 100% of the cases (16). In a systematic review, in which the results of active and passive motion protocols were evaluated postoperatively from 2006 to 2011, the rate of tendon rupture was 5% and the reduction of ROM was 6% after active motion, and a 4% tear and a 9% decrease in ROM for passive motion (16). The rate of tendon rupture after active protocols was 5.4% from 1992 to 2001 and 4% from 2002 to 2011. In another study, in which the results of early and passive motion were compared from 2006 to 2011 (17), the rupture rate was 5% for active and 7% for passive motion, which were not statistically significant (18).

In this study, the tendon rupture rate was 5.17% and the ROM results were excellent and good in 84.5% of the cases, which is similar to other studies. Studies have shown that many patients do not have the ability to perform rehabilitation programs (19,20). In one study, 67% of patients whose tendons were repaired removed their braces despite the advice of their hand therapist. 67.4% of our patients didn't perform the rehabilitation protocol at hand therapy clinics, but all carried out the protocol till the 4th week postoperatively.

Conclusion

Early active mobilization after flexor tendon repair has acceptable results with our protocol. It seems better that the rehabilitation protocol should be performed at home from the 1st to the 4th week after surgery, under the supervision of a surgeon or hand therapist; from the 4th to 6th weeks, it is recommended to be performed at hand therapy clinics, and from the 6th to 12th weeks, at home, supervised by a hand therapist.

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